REMARKS

Claims 1-6, 11, 13, 14, 17-18, 20, 22-24, 26, 28-30, 32, 34-37, 41 and 47-54 were in this case. The Examiner has rejected claims 1-6, 11, 13, 14, 18, 20, 22-24, 26, 28-30, 32, 34-37, 41 and 47-54. Claim 17 is objected to. This amendment cancels claims 5 and 6 and adds new claims 55 and 56. On entrance of this amendment, claims 1-4, 11, 13, 14, 17, 18, 20, 22-24, 26, 28-30, 32, 34-37, 41 and 47-56 are in this case.

Claim Amendments

Claim 1 has been amended to incorporate the limitations of claims 5 and 6.

Claims 5 and 6 have been cancelled in view of the amendment of claim 1.

Claim 17 has been rewritten in independent form and is now believed to be allowable.

Claim 29 has been amended to improve its clarity by reciting that it is the optical element or device that absorbs light.

Claim 36 is amended to improve antecedent basis with claim 35 and improve clarity with respect to the positioning of layers on the substrate surfaces. This amendment is supported in the specification at page 7, lines 17-22 which indicate that a face of a substrate is a surface of a substrate.

Claim 37 has been rewritten in independent form incorporating the limitations of claim 26 from which it originally depended.

Claim 51 has been amended to correct misspelling of nanotubes.

New claims 55 and 56 have been added. These claims depend from claim 1. Claim 55 is supported in the specification at page 15, lines 23-26 and in reference to Figure 1. Claim 56 is also supported on page 15 in the description of the ring cavity of the laser of Figure 1. Claim 56 is further supported by original claim 7 which referred to a ring laser configuration.

No new matter is added by this amendment.

The Rejections and Objections

Claim 51 is objected to due to the misspelling "nano5tubes." This error has been corrected.

Claims 26, 28-30, 32, 34-37, 41, 50, 52 and 54 are rejected under 35 USC 102(e) as anticipated by US 2005/0069669 (Sakaibara et al.). Applicant respectfully traverses this rejection.

The rejection asserts that Fig. 5 of Sakaibara et al. shows a pulsed laser (par. 0093) mode locking element. Paragraph 0093 of this reference states that the optical element disclosed "was operated as a variable transmittance type optical switch." The same paragraph continues and refers to Fig. 5 as showing an optical element having an optical switching function. Fig. 5 is described in paragraph 0093 as providing the outline of an experiment, it is not described as a schematic of a laser configuration. It appears in this description that a pulsed laser was used as a light source to probe the ability of the optical element to function as a switch. The description mentions a signal light and a controlling light which are produced from a laser. The experiment is said to determine the variation in quantity of light transmitted light due to the presence of absence of the controlling light. The optical element of Fig. 5 is not shown as a component of any pulsed laser. Paragraph 0093 ends by again stating that the optical element can be used as an optical switch.

Thus, on its face and in view of the description at paragraph 0093, Fig. 5 does not illustrate the use of the optical element therein as a mode-locking element. The optical element is described simply to be an optical switch. To anticipate a claim a reference must contain all the elements of claim. Sakaibara et al. does not show a laser-mode locking element or device comprising one or more layers containing carbon nanotubes as is claimed. This rejection should be withdrawn.

It may be that the Office Action makes the assumption that an optical switch is a mode-locker. The basis of such an assumption in the art prior to Applicant's invention is not clear. There is nothing of record (other than Applicant's own invention) that demonstrated that an optical element comprising one or more layers containing carbon nanotubes can function as a mode-locker in any laser configuration.

Because all the elements of the invention as claimed in claims 26, 28-30, 32, 34-37, 41, 50, 52 and 54, this rejection should be withdrawn with respect to all of the claims.
Further, the rejection is improper because it is not supported by the teachings of the reference cited.

With respect to claim 34 and claim 52 which depends there from, the Office Action states that Sakaibara et al. at para. 0022-0023 teaches varying the thickness of the carbon nanotube layers to adjust mode-locking and/or Q-switching thresholds. At these paragraphs (0022-0023), there is no mention of mode-locking or Q-switching and no discussion of adjustment of layer thickness for any purpose. Paragraph 002 discusses the diameter of SWNTs that are useful in the optical element of that invention. Paragraph 0023 again discusses the effect of SWNT diameter on the wavelength of light absorbed by the optical element. Thus, because the cited reference does not teach varying the thickness of the carbon nanotube layers to adjust mode-locking or Q-switching thresholds,

the reference does not anticipate claims 34 and 52. This rejection should be withdrawn.

Further, the rejection of claims 34 and 52 as anticipated by the cited reference is improper because it is not supported by the teachings of that reference.

With respect to claim 50, the Office Action states that Fig. 5 shows carbon nanotubes (11) in a waveguide. The Office Action appears to equate light passing through a substrate with waveguiding. The term waveguide is understood in the art to refer to particular optical elements, such as optical fibers, which are specifically structured to confine and carry light over some distance. There is no teaching or suggestion of a waveguide as the term is understood in the art in the structure of Fig. 5. Again the cited reference does not support the allegations in the rejection and the rejection is therefore improper and should be withdrawn. Because the cited reference does not teach all of the elements of the device as claimed in claim 50, the rejection should be withdrawn with respect to this claim.

With respect to claim 36, the Office Action refers to Fig. 6 as showing a substrate 12 provided with a half mirror 14 with a thin film 11 of SWNTs (carbon nanotubes). The SWNT film of Fig. 6 is provided on the mirror surface 14. Claim 36 recites a layer of carbon nanotubes provided on a substrate surface with an AR (anti-reflection) coating, a bandpass filter, or a half-mirror provided on <u>the other face of the substrate</u>. The configuration illustrated in Fig. 6 does not show a mirror on the other surface of a substrate. In contrast, it shows a layer of carbon nanotubes on a mirror surface which is on a substrate surface. There appears to be no layer of any kind on the other surface of the substrate. The reference does not teach all the elements of the laser-mode locking element or device of claim 36 and should be withdrawn.

With respect to claim 54, this claim requires (1) that the pulsed laser contain a mode-locking element or device of claim 26 which functions for mode-locking of the pulsed laser and (2) that the pulsed laser operate in the picosecond or sub-picosecond regimes. The Office Action refers to paragraph 0086 for a teaching of a femtosecond laser. The femtoscond laser discussed in this paragraph is used as a source to test the switching ability of the optical element containing carbon nanotubes. The optical element being tested is not a part of the femtosecond laser and does not function for mode-locking that laser. There is no teaching that any element or device containing carbon nanotubes can function for mode-locking of a laser to provide a pulsed laser that operates in the picosecond or sub-picosecond regimes. Again the cited reference does not support the allegations in the rejection and the rejection is therefore improper and should be withdrawn. Because the cited reference does not teach all of the elements of the device as claimed in claim 54, the rejection should be withdrawn with respect to this claim.

In view of all of the foregoing, this rejection should be withdrawn with respect to all of the claims cited in this rejection.

Claims 1-6, 11, 13-14, 18, 20, 22-24, 47-48 and 53 are rejected under 35 USC 103(a) as unpatentable over Scheps (US 6,539,041) in view of Sakaibara et al.

The rejection alleges that it would have been obvious to one of ordinary skill in the art at the time the invention was made "to provide Scheps what is taught by Sakaibara et al. to have high saturable absorption function with extremely low cost and efficiency." Applicant respectfully traverses this rejection.

The rejection refers to Fig. 1 of Scheps to show a laser comprising a number of elements including (d) one or more nonlinear optical or saturable absorber elements 110 (col. 2, lines 18-21). The Office Action alleges that Scheps lacks "one or more saturable absorber(s) comprising carbon nanotubes" and that

Sakaibara et al. teach “one or more saturable absorber(s) comprising carbon nanotubes.”

Element 110 of Scheps is labeled a “passive Q-switch” and at col. 2, lines 18-22, the patent states “Passive Q-switch 110 may be made from Cr^{4+}:YAG or a solid state host such as PMMA (Plexiglass) or ORMISIL (Sol-gel) doped with a saturable laser dye according to techniques well known in the art.” Scheps does not teach that any saturable absorber will function as a passive Q switch. Scheps refers only to materials doped with saturable laser dyes according to known techniques. Sakaibara et al. teaches only single-walled carbon nanotubes exhibit a saturable absorber function that can function for preparation of an optical switch. Sakaibara et al. does not teach that single-walled carbon nanotubes have a saturable absorber function that can function for passive Q-switching or for mode-locking of a laser.

Claim 1 has been amended to incorporate the recitations of claims 5 and 6. Claim 1 now recites that at least one of the saturable absorber elements containing carbon nanotubes is a mode locker and that the laser is self-starting and mode-locked.”

Applicant again stresses that neither of Scheps or Sakaibara et al. teaches that carbon nanotubes can be used as a saturable absorber that can function as a mode-locker in a laser and that the mode-locked laser employing such a saturable absorber will be self-starting.

With respect to claim 5, the rejection refers to page 2 of the specification for an “admission” apparently with respect to the equivalence of a saturable absorber device and a mode-locking device. Applicant makes no such admission. On page 2 (paragraph bridging pages 2 and 3) of the specification, Applicant states:

> Therefore, a mode locker, is a type-of saturable absorber that exhibits additional properties beneficial for functioning to mode lock a laser. A mode locker material, which is the functional material in

> a mode-locker element or device useful in laser configuration herein, should preferably possess both a fast and a slow recovery time in order to be used effectively in a pulsed laser operating in the picosecond and sub-picosecond regimes. There are many materials possessing nonlinear properties (such as saturable absorption) that do not possess the properties of a mode-locker. The CNT materials including layers containing SWNTs, or a combination of SWNTs and MWNTs exhibit mode-locker properties.

In this passage, Applicant teaches for the first time that a saturable absorber containing carbon nanotubes has properties necessary for its function as a laser mode-locker.

With respect to claim 6, the Office Action alleges that Sakaibara et al. disclose in paragraph 0093 the mode locker is an optical pulse-initiating, self-starting element. The teachings found in paragraph 0093 are discussed above. Applicant finds no teaching in this paragraph that the optical device containing carbon nanotubes that is disclosed can function as a mode locker and further there is no disclosure in this paragraph that the optical device is an optical-pulse-initiating, self-starting element as alleged in the Office Action. Thus, the reference cited does not support the rejection and the rejection is as such improper.

With respect to claim 14, the Office Action states that Sakaibara et al. in paragraph 0093 discloses optical pulses of length less than 1 picosecond. In this paragraph, a femtosecond laser is described as used to assess the use of the optical device of the patent application as an optical switch. The optical switch of the cited patent application is not a component of the femtosecond laser mentioned in this paragraph.

With respect to claim 23, the Office Action alleges that paragraph 0064 of Sakaibara et al. discloses that the carbon nanotubes employed comprise 505 or

more by weight of semiconductor carbon nanotubes. This paragraph discusses the use of purified SWNTs, but does not indicate the level of purity employed.

In view of the foregoing, this rejection should be withdrawn with respect to all claims.

Claims 49 and 51 are rejected under 35 USC 103(a) as unpatentable over Scheps (US 6,539,041) in view of Sakaibara et al. and in further view of Risch et al. (20040109652). Applicant respectfully traverses this rejection.

The Office Action states that Scheps and Sakaibara et al. disclose all limitations of the claims “except for the carbon nanotubes are optical fibers.” Risch et al. is stated to teach the carbon nanotubes are optical fiber. These claims are rejected because it is alleged that the invention as claimed “would have been obvious to one of ordinary skill in the art at the time the invention was made to provide Scheps and Sakaibara et al. to save cost and protect the fiber from the possible attenuation of the signal transmitted”. The Office Action refers to paragraphs 0015 and 0016 apparently of Risch et al.

Risch et al. relates to fiber optic cables with a hydrogen absorbing material. The abstract of the patent application recites an optical fiber that is enclosed in a sheath and that a hydrogen absorbing material is positioned between the sheath and the optical fiber. The hydrogen absorbing composition includes an oil, a thixotropic agent, an oxidant system and a carbon nanostructure component which can be carbon nanotubes. Thus, Risch et al. does not disclose optical fibers comprising carbon nanotubes, the reference discloses optical fibers that are surrounded with a composition that can include carbon nanotubes.

Claim 49 recites that the one or more nonlinear optical or saturable absorber elements or devices containing carbon nanotubes of the laser are optical fibers and thus requires that the optical fiber itself contains carbon nanotubes. Claim

51 recites a mode locking element or device wherein the carbon nanotubes are in an optical fiber, and again requires that the optical fiber itself contains carbon nanotubes. Risch et al. does not teach an optical fiber containing carbon nanotubes.

Combination of the optical fiber cables of Risch et al. with the teachings of Scheps and Sakaibara et al. would not result in the invention as claimed in claims 49 and 51. The invention as claimed in claims 49 and 51 is thus not made obvious by the combination of references recited in this rejection.

Further the teachings of Risch et al. do not support the allegations of the rejection. As such the rejection is improper and should be withdrawn.

As noted above, the specification on page 15 teaches that a saturable absorber device suitable for ultra-fast laser mode-locking has "both a fast and a slow recovery time for mode-locking and self-starting, respectively, of a laser (with the fast component dominating over slow component so that mode-locking will dominate over Q-switching mode), a suitable level of saturation fluence depending on the laser peak pulsed power to facilitate stable mode-locking (a laser will not mode-lock if the saturation fluence is too high, and will become unstable if the saturation fluence is too low.), a suitable nonlinear absorption level (high saturable absorption level could give rise to Q-switch instabilities, whilst mode-locking will not occur if the saturable absorption level is too small) an absorption level in the range of about 0.2dB to about 1.2dB is found to be a good mode-locking operating range."

Applicant has submitted a Supplemental Information Disclosure statement which provides several references which discuss the properties of saturable absorbers required for mode locking of lasers. For example, Haus (1976) states in column 1, page 1074:

> The existence of steady-state mode-locked pulse solutions does not guarantee that these will be realized in practice. In fact, the scarcity of successful experiments of mode locking of a

> homogeneously broadened CW laser by a saturable absorber suggests that, more likely than not, the mode locking may be prevented by some other instability such as the well-known relaxation oscillations [3], or may not be self-starting.

This statement supports Applicant's arguments that it is understood in the art that not all saturable absorbers can be successfully employed for laser mode-locking, for example, because of instabilities or because they may not be capable of self-starting.

Additionally, a more recent reference Jiang et al (1999) indicates that saturable absorbers, particularly when used in Er-doped fiber lasers (as in new claims 55 and 56) must have balanced properties to be useful for mode-locking:

> Erbium fiber lasers are quite distinct from bulk solid-state lasers insofar as mode-locked operation with large intracavity losses (.20 dB) is possible, and the long lifetime of erbium in silica glass makes erbium fiber lasers susceptible to *Q*-switching instability. Therefore the design of SA's that are suitable for mode locking erbium fiber lasers presents unique challenges because of apparently conflicting requirements. On the one hand, large nonlinearity (saturable loss) is required for a strong starting mechanism, especially when the laser is optimized for high output power. On the other hand, the size of the nonlinearity must be limited to avoid *Q*-switching instabilities.

There is no teaching or suggestion in Sakaibara et al. that a saturable absorber containing carbon nanotubes has the balance of properties needed for laser mode-locking. There is no teaching of appropriate recovery times, suitable saturation fluence, or a suitable nonlinear absorption level for a saturable absorber containing carbon nanotubes. Without such information or the experimental demonstration that Applicant has provided, one of ordinary skill in the art could not predict with any reasonable degree of success whether or not a saturable absorber comprising carbon nanotubes would provide for self-starting and stable mode locking of any laser.

Because the cited references do not teach or suggest the use of a saturable absorber containing carbon nanotubes as a mode locker for any laser, this

rejection should be withdrawn. Because it was and is known in the art that it can not be predicted with any reasonable certainty, in the absence of additional information, that a given saturable absorber material will have the additional properties needed for mode-locking a laser, the cited references do not make obvious the invention as claimed.

In view of all the foregoing the rejections under 35 U.S.C. 103 should be withdrawn.

Response to Arguments Previously Presented

The Office Action indicates that arguments presented previously by Applicant have been considered, but are not persuasive.

The Office Action states that the examiner does not concur with Applicant's argument that Figure 5 of the Sakaibara et al. reference does not teach a laser mode-locking element containing carbon nanotubes to generate laser pulses. The Office Action then refers more broadly to paragraphs 0083 to 0093 of the Sakaibara et al. reference. It is unclear to Applicant what information provided in these paragraphs is being used by the examiner to support the allegation that Fig. 5 teaches a mode locking device containing carbon nanotubes to generate laser pulses.

The paragraphs discuss that the carbon nanotubes exhibit a saturable absorbed property. As noted above and discussed in Applicant's specification, the mere fact that a material exhibits a saturable absorption property is not sufficient to allow one of ordinary skill in the art to predict with any reasonable degree of certainty that that material can be used to mode lock a laser and generate a stable laser pulses.

The paragraphs also discuss the Z-scan method for measuring a saturable absorber effect. In this method a femtosecond pulsed laser is used as a laser beam source for the measurement. However, in this method the saturable absorber element does not mode lock the laser and is not used to generate laser pulses. The laser input into the Z-scan method is already pulsed.

Applicant respectfully requests clarification of the basis of the novelty and obviousness rejection over Sakaibara et al. On its face, the teachings of Sakaibara et al., in the paragraphs noted and particularly in Fig. 5, refer to an optical element that is an optical switch. There is no teaching of laser mode locking by this optical switch.

Allowable Subject Matter

Claim 17 is said to be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claim. Claim 17 has been amended to comply with these requirements and is believed to now be allowable.

Conclusion

A Petition for Extension of Time for Three Months accompanies this submission. A fee of $525.00 (small entity) is believed to be due. It is believed that this response requires the payment of excess claims fees for two additional independent claims ($210.00). It is intended that fee payments of $735.00 will be submitted upon electronic filing of this submission. If the fees are not paid or are incorrect, the U.S. Patent Office is authorized to deduct any fee deficiency or credit any overpayment to deposit account 07-1969.

Respectfully submitted,

/sallyasullivan/

Sally A. Sullivan
Reg. No. 32,064

Greenlee, Winner and Sullivan, P.C.
4875 Pearl East Circle, Suite 200, Boulder, Colorado 80301
Phone: (303) 499-8080; FAX: (303) 499-8089
Email: Winner@Greenwin.com
Attorney Docket No. 148-02
SAS:bds: November 26, 2007